SOUTHWEST FISHERIES CENTER

NATIONAL MARINE FISHERIES SERVICE HONOLULU LABORATORY 2570 DOLE STREET HONOLULU, HAWAII 96822-2396

MARCH 1995

LIBRARY
NOAA, NMFS Honolulu Lab.
2570 Dole St.
Honolulu, Hawaii 96822-2396

STATUS OF LOBSTER STOCKS IN THE NORTHWESTERN HAWAIIAN ISLANDS, 1994

WAYNE R. HAIGHT
AND
GERARD T. DINARDO

Honolulu Laboratory
Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
Honolulu, Hawaii 96822-2396

ADMINISTRATIVE REPORT H-95-03

This Administrative Report is issued as an informal document to ensure prompt dissemination of preliminary results, interim reports and special studies. We recommend that it not be abstracted or cited.

Southwest Fisheries Science Center
Administrative Report H-95-03

Status of Lobster Stocks in the Northwestern Hawaiian Islands, 1994

Wayne R. Haight[1] and Gerard T. DiNardo[2]

[1]Honolulu Laboratory
Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
2570 Dole Street, Honolulu, Hawaii 96822-2396

[2]Marine Resource Dynamics and Assessment Program
Joint Institute for Marine and Atmospheric Research
University of Hawaii
1000 Pope Road
Honolulu, Hawaii 96822

March 1995

INTRODUCTION

The Northwestern Hawaiian Islands (NWHI) trap fishery for spiny lobster *(Panulirus marginatus)* and slipper lobster (*Scyllarides squammosus*) began in the late 1970's after federal and state exploratory research cruises located lobster stocks in quantities suitable for commercial exploitation (Uchida et al., 1980). Lobster landings reached a maximum in 1984 and gradually declined during the years 1985 through 1989. A substantial decrease in lobster landings and catch-per-unit-effort (CPUE) was observed in 1990 and continued through 1991, prompting an emergency closure of the fishery from May 8 through November 11, 1991 (Haight and Polovina, 1992). To allow the lobster population to rebuild to a sustainable exploitation level, the lobster fishery has been managed under a quota and limited entry system since 1992.

A fishery independent survey is conducted annually by the National Marine Fisheries Service (NMFS) Honolulu Laboratory to provide additional information on the dynamics of the NWHI lobster population. The results of the analyses of research and commercial fishery data are presented in this report, the 10th in an annual series of NWHI lobster status reports. In addition, a detailed description of the quota methods outlined here can be found in Wetherall et al. (1995).

FISHERY MANAGEMENT

The NWHI lobster fishery is managed by NMFS under the Crustaceans Fishery Management Plan (FMP) adopted in 1983 by the Western Pacific Regional Fishery Management Council. The FMP defines a minimum legal size for harvested lobsters, requires the use of escape vents on traps, forbids the retention of berried females, and requires that vessel captains submit logbooks of daily catch and fishing effort. In response to substantial declines in CPUE in 1991, the FMP was amended in 1992 to include an annual 6-month closed season (January-June), limit entry into the fishery and establish an annual catch quota.

The annual quota is derived as a two-step process (1) a pre-season forecast quota is issued in February based on the results of commercial and research fishing from the previous year, and (2) an in-season (August) adjustment is made based on CPUE information from the first month of commercial fishing. The quota is set at a level that provides an economically viable CPUE (1.0 lobster/trap-haul), while protecting spawning stock biomass from over-harvest. The NWHI lobster quota is based on an optimal biomass approach, allowing surplus production to be harvested if the population is above the optimal level. The quota methodology was first applied during the 1992 fishing season. The 1993 preseason forecast indicated that the lobster stock size would be insufficient to permit a commercial fishery in 1993. Based on this information, the fishery remained closed from 1993 through June of 1994. The 1994 pre-season forecast indicated that the population would rebuild to a level which would allow a fishery during the 1994 season, and the fishery was opened July 1,

1994. Commercial CPUE from the first month of fishing indicated the population was smaller than predicted, and the fishery was subsequently closed.

RESEARCH PROGRAM

A fishery independent trap survey is conducted annually by the NMFS Honolulu Laboratory to collect length frequency, sexual development, and relative abundance data from lobster stocks in the NWHI. The survey uses a fixed site design stratified by depth and spans the years 1986-88 and 1990-94. The number of sample sites varied temporally as did trap type. Seven sites were sampled at Necker Island and six sites at Maro Reef each year from 1986 through 1988. Beginning in 1990, six sites were sampled at Necker Island and five sites at Maro Reef. At each site, shallow water (≤20 fathoms) and deep water (>20 fathoms) stations were sampled. Ten strings of eight traps each were set at the shallow station and two to four strings of 20 traps each were set at the deep station. Between 1986 and 1990 wire traps were used as the primary sampling gear. In 1991, a combination of wire and plastic traps were fished to facilitate the estimation of gear conversion formulae (wire trap CPUEs to plastic trap CPUEs); plastic traps have been used exclusively since 1991. Traps are fished overnight and baited with frozen mackerel.

Length frequencies of spiny lobster are converted to age frequencies by applying a growth curve estimated by Polovina and Moffitt (1989). Based on this growth curve, recruitment of spiny lobster to the commercial fishery is estimated to occur approximately 3 years after settlement onto the benthos. Age-specific CPUE values are calculated by dividing total number of spiny lobster of each age class by the total number of traps fished at each bank and are standardized by applying the conversion factor for gear type.

In 1994, standard research trapping was conducted at Maro Reef and Necker Island from May 8 to May 28. Additional exploratory trapping for juvenile lobsters was conducted from small boats in the shallow lagoon at Maro Reef, continuing a time series of juvenile abundance data collection which began in 1993.

ABUNDANCE

A significant reduction in research CPUE values for all spiny lobster age classes at Maro Reef was first observed in 1990. The depressed CPUE continued from 1991 through 1994 (Fig 1.). This trend has persisted despite significant reductions in commercial fishing effort at Maro Reef during 1991-92 and 1994, and a fishery closure in 1993. A similar trend was observed at Laysan Island, 70 nmi to the northwest (Haight and Polovina 1992), which has been closed to commercial harvest since the beginning of the commercial fishery. In contrast, recruitment of age 2 lobster to Necker Island, 360 nmi to the southeast of Maro Reef, remained fairly constant throughout the time series (Fig. 2). Polovina and Mitchum (1992) found recruitment of spiny lobster to Maro Reef to be correlated with the strength of the subtropical countercurrent, suggesting that mesoscale oceanographic features may impact the

transport and survival of lobster larvae during their 11-12 month pelagic larval cycle. Continued recruitment of spiny lobster to Necker Island suggests that the lower southeastern end of the NWHI is not linked to the same oceanographic or recruitment processes as the northwestern end of the archipelago. Because the oceanographic processes which appear to affect recruitment at the northwestern portion of the NWHI occur in approximately decadal cycles (Polovina and Mitchum, 1992; Polovina et al., 1994), the spiny lobster stocks may remain at the present level of production for several years.

At Necker Island, juvenile spiny lobster (<age 3) appear to occupy the same habitat as the adults (Parrish and Polovina 1994), which increases the probability of being caught in the commercial fishery. It is likely that fishery-related mortality (handling stress, predation on discards) of juvenile lobster is quite high. At Maro Reef, juvenile lobster appear to utilize shallow reef areas not associated with fishing. In 1993, an area of high juvenile abundance was located during exploratory research trapping in the shallows of Maro Reef (Haight and Polovina 1993a). In 1994, the same lagoonal areas were fished, and the area of high juvenile abundance was extensively surveyed. Age specific CPUE values from inside Maro Reef were significantly higher than the CPUE values from outside the reef (Fig. 3). Of the shallow lagoon areas trapped in 1994, only the northwestern reef spur site exhibited high juvenile CPUE values (Fig. 4). It appears that the juvenile lobster are associated with the northern portion of the reef spur and are more abundant in shallow waters next to the spur (Fig. 5). The deeper (12 m) station to the south of the spur had relatively low CPUE values compared to the shallow water stations.

SPAWNING STOCK BIOMASS

The spawning potential ratio (SPR), based on the spawning stock biomass per recruit, is specified in the FMP as the measure of overfishing for the NWHI lobster stocks. The FMP defines a SPR value of ≤0.20 as the indicator of recruitment overfishing. The 1994 SPR value of 0.76 indicates that the amount of fishing effort in 1994 (168,498 trap-hauls) would be insufficient to cause recruitment overfishing under average conditions.

The SPR value however, does not consider changes in the level of recruitment and subsequent trends in spawning biomass. An index of spawning stock biomass can be calculated from research CPUE. This index is the ratio of the current year's spawning biomass (kg/trap-haul) to the spawning biomass for the unexploited population. To determine the spawning biomass for a given year, the size at onset of sexual maturity must first be determined. A standard method of determining this parameter is the size at the onset of egg production in female lobsters (Haight and Polovina, 1993a). A hyperbolic tangent function (Polovina, 1989) was fit to the 1994 research data to determine the size at which 50% of the females were ovigerous. This value was then used to calculate the biomass of reproductively mature spiny lobster for 1994. The 1994 value was compared to the value for the unexploited stock (pre-fishery data from 1977) to calculate the spawning biomass index value. The index values declined substantially in 1990, concurrent with the commercial fishery CPUE decline,

and remained low until 1992. Since 1992 there has been a gradual trend toward increased spawning biomass at Necker Island (Table 1).

The difference in the two approaches above should be noted. The SPR indicates that on the average, 168,000 trap-hauls would not result in recruitment overfishing, whereas the spawning biomass ratio indicates the reproductive potential of the stock, especially at Maro Reef, has substantially decreased from pre-exploitation levels .

DYNAMIC POPULATION MODEL

Several approaches have been used since 1983 to model the lobster population in the NWHI. From 1985 to 1987, lobster yield was estimated using surplus production methods. After 1988, a dynamic population model was fit to the commercial data to estimate population size and biological parameters. This model expresses the number of exploitable lobster in a given month as a function of the number of exploitable lobster in the previous month, adjusted for natural mortality, fishing mortality, and recruitment. Because of spatial and temporal fluctuations in fishery dynamics, the monthly catches of both lobster species were pooled across banks to calculate a NWHI monthly average CPUE. The model predicted CPUE values for the years 1983 to 1989 fit the general commercial CPUE trend quite well; however, after 1989 the predicted CPUE values were consistently higher than the actual commercial CPUE values. Based on oceanographic and research assessment information (Polovina and Mitchum, 1992; Haight and Polovina, 1993b) it was assumed that the disparity between the estimated and actual CPUE values reflected a change in recruitment and not in natural mortality or catchability. The model was subsequently updated to incorporate variable recruitment, and refit to the commercial CPUE data (Haight and Polovina, 1993b).

QUOTA COMPUTATIONS

To provide the 1994 preliminary quota forecast, the dynamic population model was used to estimate a CPUE value for the first month of fishing based on commercial data through December 1992. The forecast July 1994 CPUE was 1.037 lobster/trap-haul. This resulted in a preseason forecast quota of 200,000 lobster. Research trapping prior to the commercial fishing season indicated that lobster stocks were at the level predicted by the dynamic population model. However, commercial CPUE from the first month of fishing was lower than predicted by the dynamic population model (0.91 vs 1.037) resulting in a reduction of the quota to 20,900 lobster (Fig. 6). Because the commercial catch exceeded the in-season final quota when announced, the fishery was closed in mid-August. During the 1994 fishery, a total of 130,979 lobster were caught in 168,498 trap-hauls. Spiny lobster comprised 65% of the total lobster caught (Table 2).

The large in-season reduction in the 1994 quota caused concern among fishery managers and the fishing industry. Therefore, to address the apparent sensitivity of the quota procedure to relatively small changes in CPUE, the NMFS formed an ad hoc review panel of fishery

experts to investigate modifications to the lobster population modelling and quota methodology. After a thorough examination of the data time series, population modelling and quota methodology, the review panel suggested the following additional research to improve the quota procedure: (1) investigate standardizing the CPUE time series for confounding effects (fluctuating fishery dynamics, changes in fishing power) using general linear modelling procedures; (2) examine the hypothesis that the decline in the CPUE time series reflects a change in recruitment. Check this against the possibility that changes in vessel efficiency, targeting or changes in natural mortality or catchability could have been factors in the decline; (3) investigate a revised quota setting procedure, where uncertainty in the assessment is incorporated, and the goal is to find a quota which gives a low risk of the stock being overfished in any year.

UPDATED POPULATION MODEL AND QUOTA FORECAST

The review panel recommended sensitivity analyses to determine how large a change in the model estimate of catchability (q) and natural mortality (M) would be needed to explain the observed pattern in catch rate data. To address this recommendation, the population model was run allowing q to vary after 1989, while holding recruitment and M constant; this resulted in an approximately 50% reduction in q. There is no evidence from the commercial fleet to support a drop in q of this magnitude; fishing strategies and vessel efficiencies have remained fairly constant. Also, this result is inconsistent with research vessel CPUE data which detected a drop in CPUE, similar to that observed in the commercial CPUE series, between 1989 and 1990. When the model estimates of recruitment and q were held constant, and M allowed to vary after 1989, M increased by a factor of about three. Currently, there is no evidence to support a change in M of this magnitude. In summary, it is likely that the observed changes in catch rate between 1989 and 1990 were the result of changes in recruitment and not q or M.

Previously, monthly lobster abundance indices had been computed as the observed arithmetic average CPUE. As recommended by the review panel, a general linear model (GLM) analysis of CPUE was conducted to determine the effects of various factors on average CPUE and to compute indices of abundance adjusted for such effects. After investigating various factors, the data were adjusted to include spatial fluctuations in CPUE across the time series.

The dynamic population model was fit to the adjusted 1983-94 commercial CPUE data to estimate the July 1995 CPUE. Using this value (0.952 lobster/trap-haul), the population at the beginning of the 1995 fishing season is estimated to be 1,328,202 lobsters. Using the population estimate in the FMP quota formula yields a 1995 preliminary catch quota of 38,513 lobster. For a detailed description of the above procedures see Wetherall et al. (1995).

DISCUSSION

The objective of regulations outlined in Amendment 7 to the Crustaceans FMP is to protect the NWHI lobster stock from overfishing, ensure the maintenance of optimal spawning biomass, and allow the fishery to harvest surplus production. Implemented in 1992, Amendment 7 provided a framework with which to rebuild the NWHI lobster stock. Under the provisions outlined in the amendment, the lobster population was allowed to rebuild beginning with a quota in 1992, a closure of the fishery in 1993, and a small fishery in 1994. By examining the model-based estimate of the average NWHI exploitable population size, it can be seen the population has increased every year since 1992 (Fig. 7). The spawning biomass ratio also reflects this trend (Table 1). It appears that the recruitment process in the NWHI differs between the southeastern and northwestern portions of the archipelago, and that recruitment remains low in the northwestern portion relative to the pre-1990 level. There is also indication that spawning biomass has not increased substantially in the northwestern region. Future research, and associated management decisions must integrate several factors, including the dynamics of NWHI spiny lobster recruitment, the potentially high mortality of discarded sublegal lobsters, and the sensitivity of the FMP Amendment 7 quota formula to small changes in CPUE. The NMFS Honolulu Laboratory Stock Assessment Investigation is currently studying ways to refine the population modeling procedure, and to develop a new quota system that minimizes the risk of overfishing while providing greater quota stability and dependability (see Wetherall et al. 1995).

ACKNOWLEDGMENTS

Figures 1 and 2 were created using the Generic Mapping Tools (version 2.1.4) program (Wessel and Smith 1991).

REFERENCES

Haight, W. R., and J. Polovina.
1993a. Status of lobster stocks in the Northwestern Hawaiian Islands, 1993. Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-93-17, 13 p.

Haight, W. R., and J. Polovina.
1993b. Status of lobster stocks in the Northwestern Hawaiian Islands, 1992. Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-93-04, 23 p.

Haight, W. R., and J. Polovina.
1992. Status of lobster stocks in the Northwestern Hawaiian Islands, 1991. Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-92-02, 19 p.

Parrish, F. A., and J. J. Polovina.
1994. Habitat thresholds and bottlenecks in production of the spiny lobster (*Panulirus marginatus*) in the Northwestern Hawaiian Islands. Bull. Mar. Sci. 54(1):151-163.

Polovina, J. J.
1989. Density dependence in the spiny lobster, *Panulirus marginatus*, in the Northwestern Hawaiian Islands. Can. J. Fish. Aquat. Sci. 46:660-665.

Polovina, J.J., and G.T. Mitchum.
1992. Variability in spiny lobster *Panulirus marginatus* recruitment and sea level in the Northwestern Hawaiian Islands. Fish. Bull., U.S. 90:483-493.

Polovina, J. J., and R. B. Moffitt.
1989. Status of lobster stocks in the Northwestern Hawaiian Islands, 1988. Honolulu Lab., Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-89-03, 10 p.

Polovina, J. J., G. Mitchum, N. Graham, M. Craig, E. DeMartini, and E. Flint.
1994. Physical and biological consequences of a climatic event in the central North Pacific. Fish. Oceanogr. 3(1):15-21.

Uchida, R. N., J. H. Uchiyama, R. L. Humphreys, Jr. and D. T. Tagami.
1980. Biology, distribution, and estimates of apparent abundance of spiny lobster *Panulirus marginatus*, in waters of the Northwestern Hawaiian Islands. *In*: Grigg, R., and R. Pfund (eds.), Proceedings of the symposium on the status of resource investigations in the Northwestern Hawaiian Islands, Honolulu, HI, April 24-25, 1980. UNIHI-SEAGRANT-MR-80-04. University of Hawaii Sea Grant College Program, Honolulu.

Wessel, P., and W. Smith.
1991. Free software helps map and display data. EOS Trans. Amer. Geophys. U. 72:441, 445-446.

Wetherall, J. A., W. Haight, and G. DiNardo.
1995. Computation of the preliminary 1995 catch quota for the Northwestern Hawaiian Islands lobster fishery. Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-95-04, 30 p.

Table 1. Ratio of exploited/unexploited spawning stock biomass (kg/trap-haul) for spiny lobster.

Year	1977	1988	1990	1991	1992	1993	1994
Necker Island	1[a]	0.51	0.27	0.27	0.36	0.36	0.45
Maro Reef	1[b]	0.80	0.17	0.09	0.07	0.08	0.08

[a] Necker Island - 2.45kg/trap-haul
[b] Maro Reef - 2.14kg/trap-haul

Table 2. Annual landings of spiny and slipper lobster (1,000's), trapping effort (1,000 trap-hauls), and the percentage of spiny lobster in the landings, 1983-92[a].

Year	Spiny lobster	Slipper lobster[b]	Total lobster	Effort	CPUE	Percent spiny lobster
1983[c]	158	018	176	64	2.75	90
1984	677	207	884	371	2.38	78
1985	1,022	900	1,902	1,041	1.83	57
1986	843	851	1,694	1,293	1.31	54
1987	393	352	745	806	0.92	57
1988	888	174	1,062	840	1.26	84
1989	944	222	1,166	1,069	1.09	81
1990	591	187	777	1,182	0.66	76
1991[d]	131	035	166	296	0.56	79
1992[e]	260	164	424	722	0.59	61
1994[f]	085	046	131	168	0.78	65

[a] Data are provided to the National Marine Fisheries Service as required by the Crustacean Fishery Management Plan of the WPRFMC and are compiled by the Fishery Management Research Program, Honolulu, Laboratory.

[b] Slipper lobster landings, 1984-87 are 72% of those reported. The adjustment was made to account for a minimum size change in 1987.

[c] April-December 1983.

[d] January-May, November-December 1991

[e] January-April, July-December 1992

[f] July-August, 1994

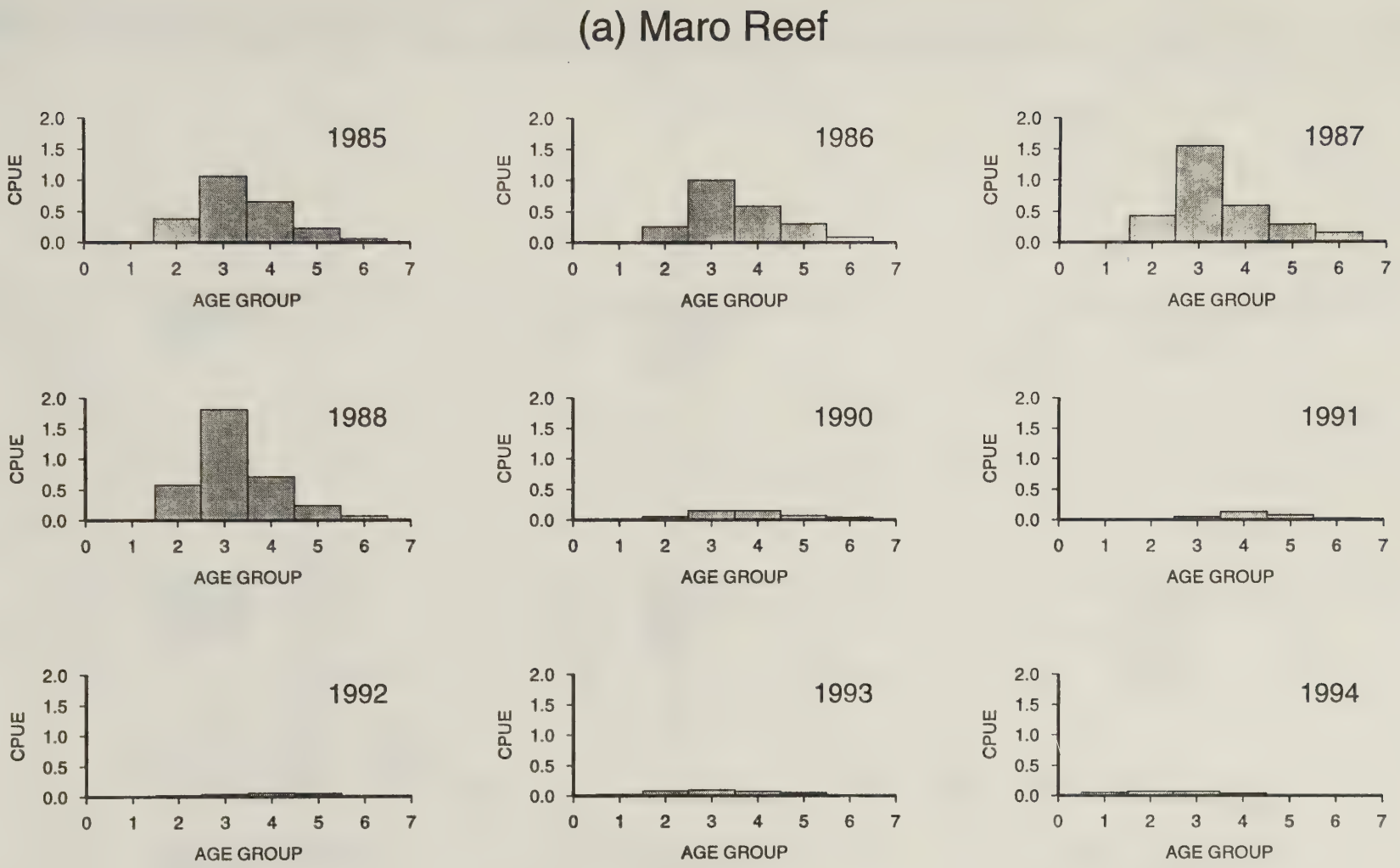

Figure 1. Age-specific CPUE of spiny lobsters caught in the *Townsend Cromwell* research surveys at Maro Reef.

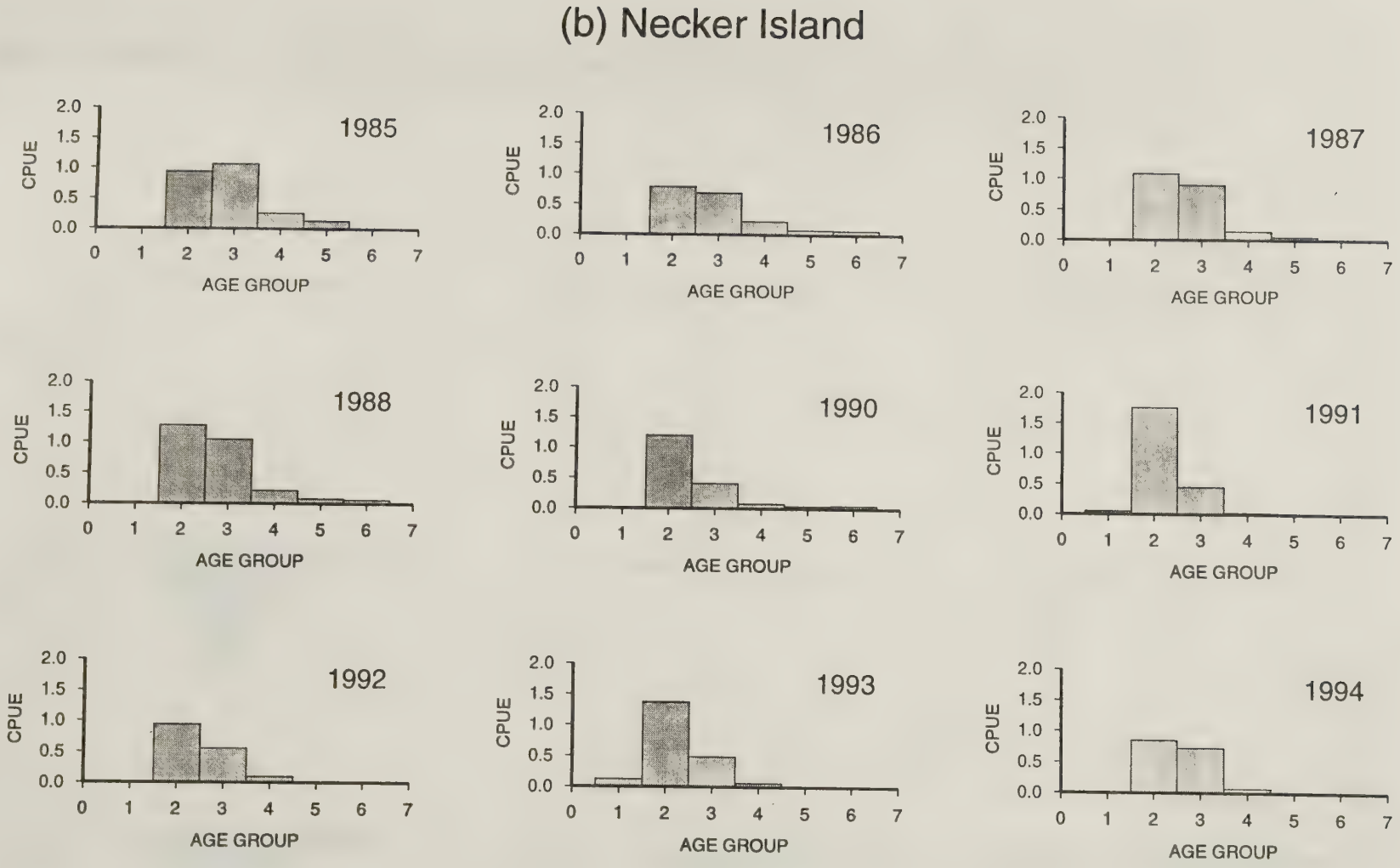

Figure 2. Age-specific CPUE of spiny lobsters caught in the *Townsend Cromwell* research surveys at Necker Island.

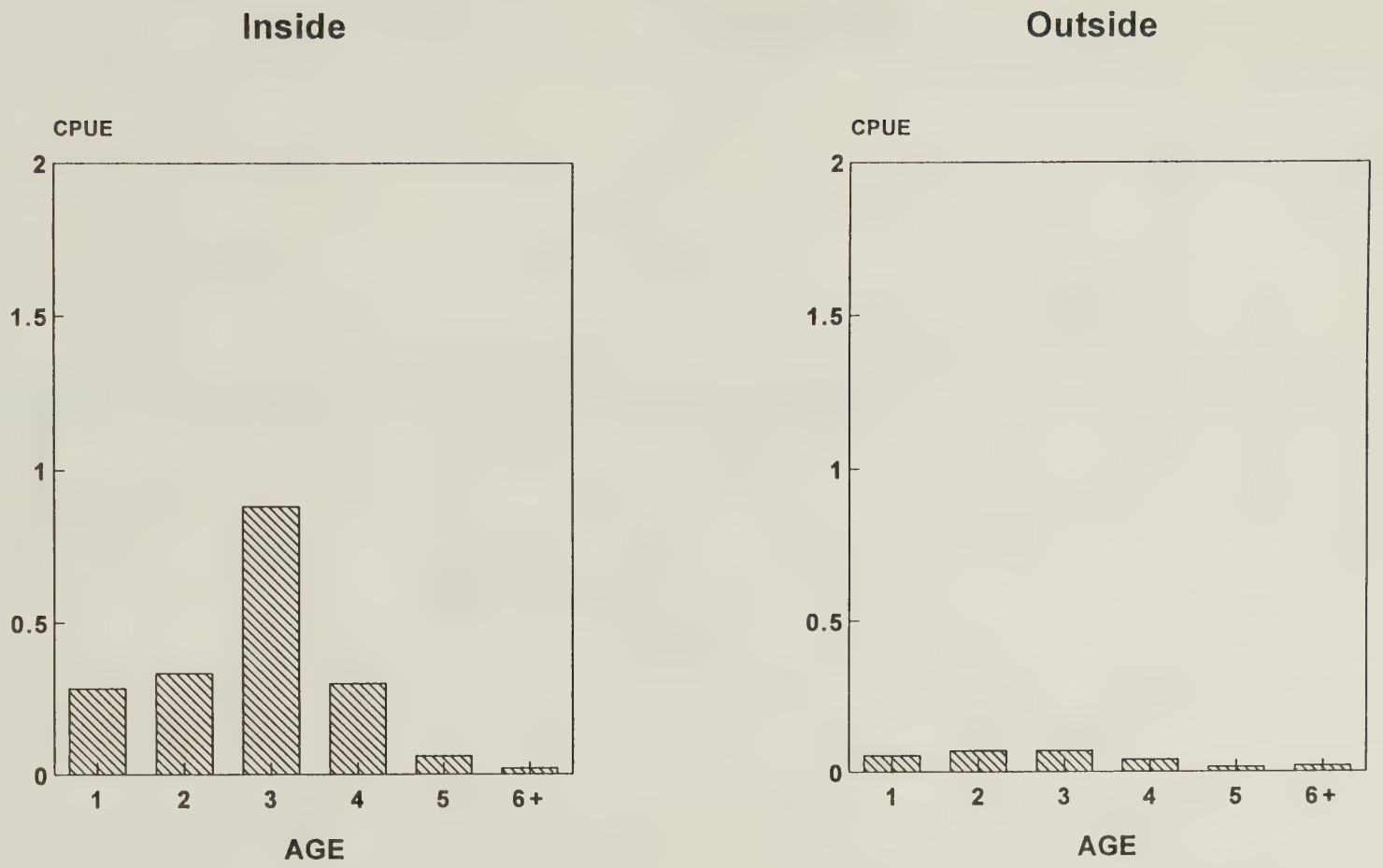

Figure 3. Age-specific CPUE of spiny lobsters caught in the *Townsend Cromwell* research surveys, inside vs outside Maro Reef.

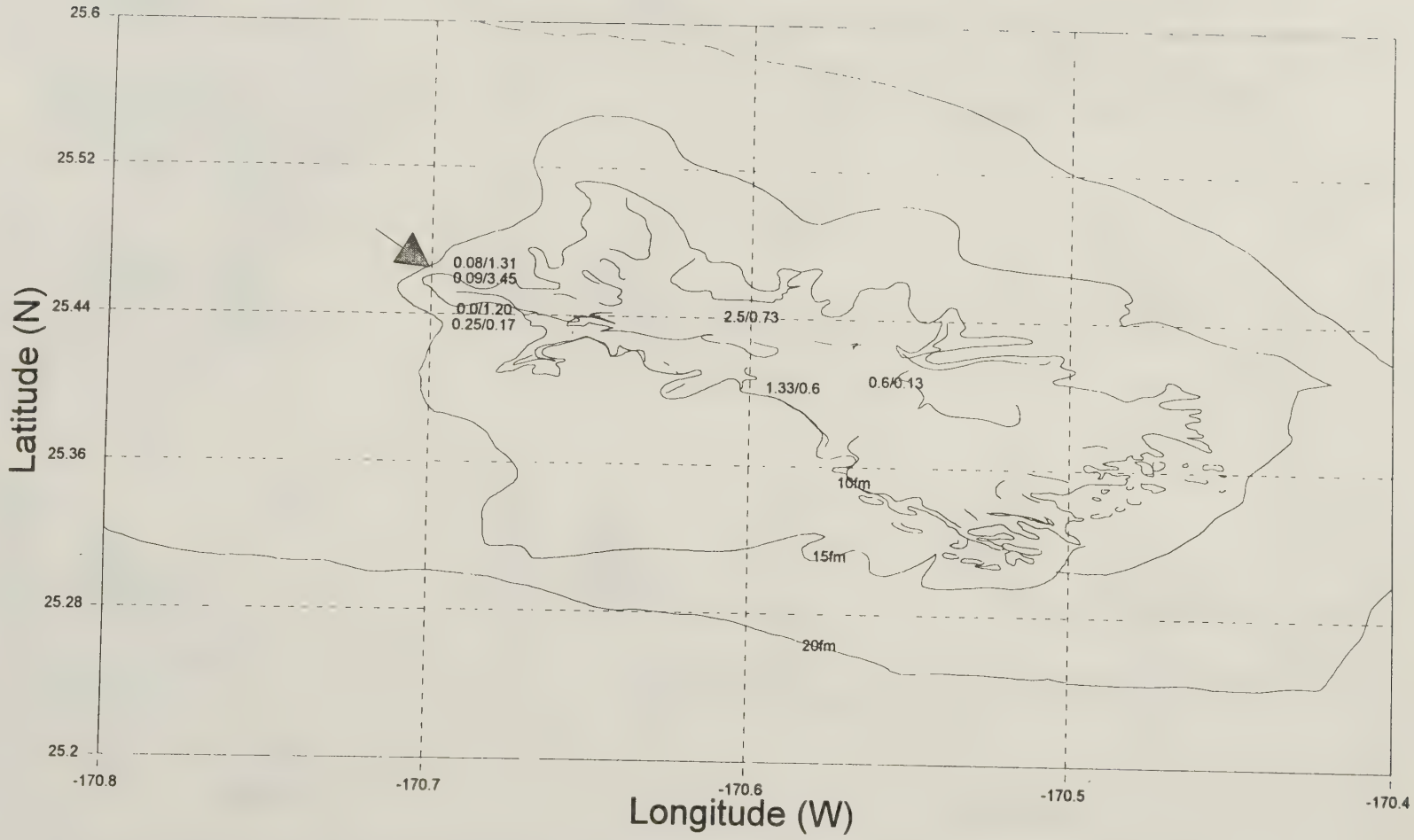

Figure 4. Research CPUE values inside Maro Reef. The adult CPUE value is to the left of the backslash, the juvenile to the right. The arrow denotes the area of high juvenile abundance.

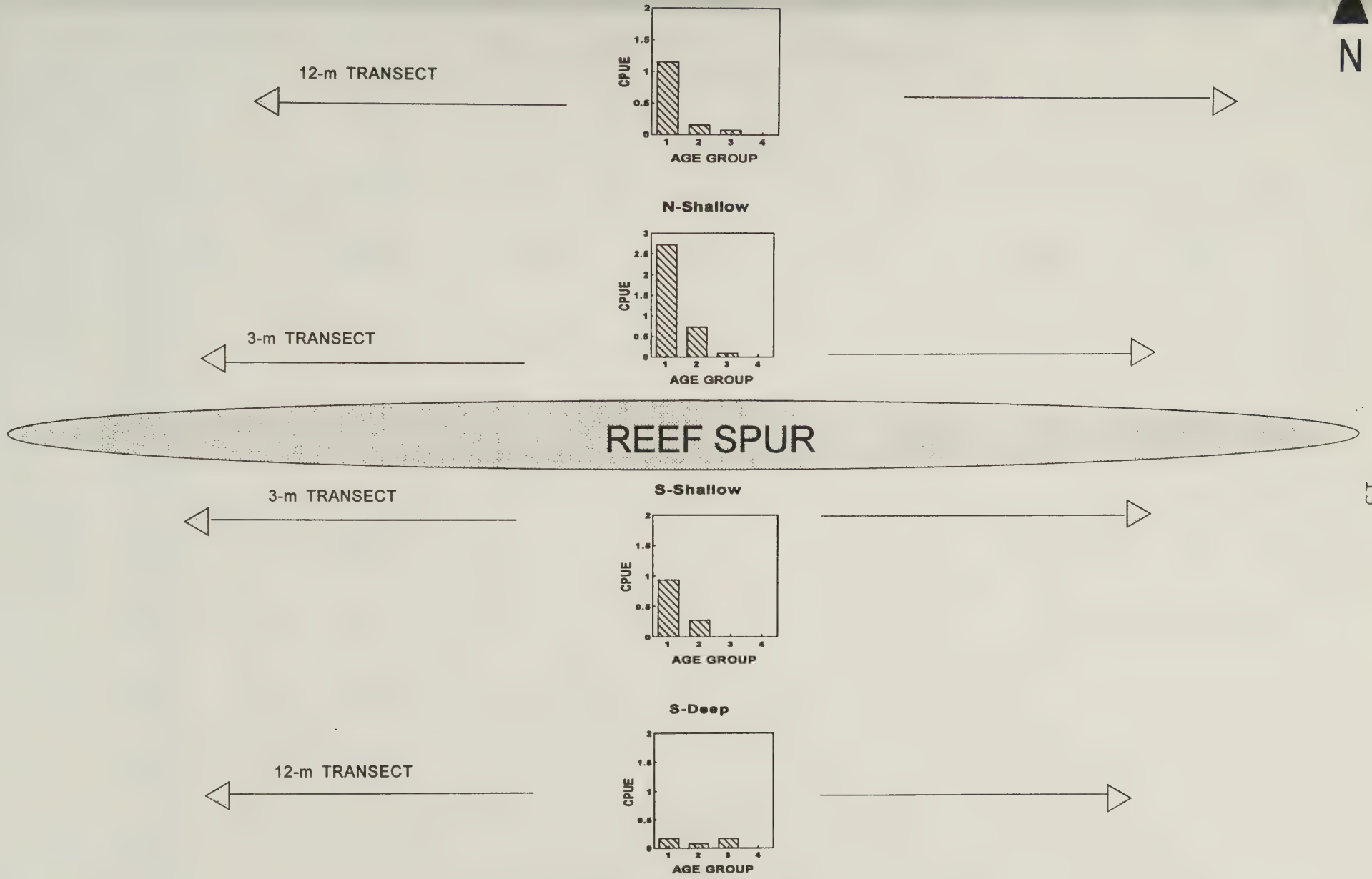

Figure 5. Research CPUE values at the northwestern reef spur, the area indicated by the arrow in Figure 4.

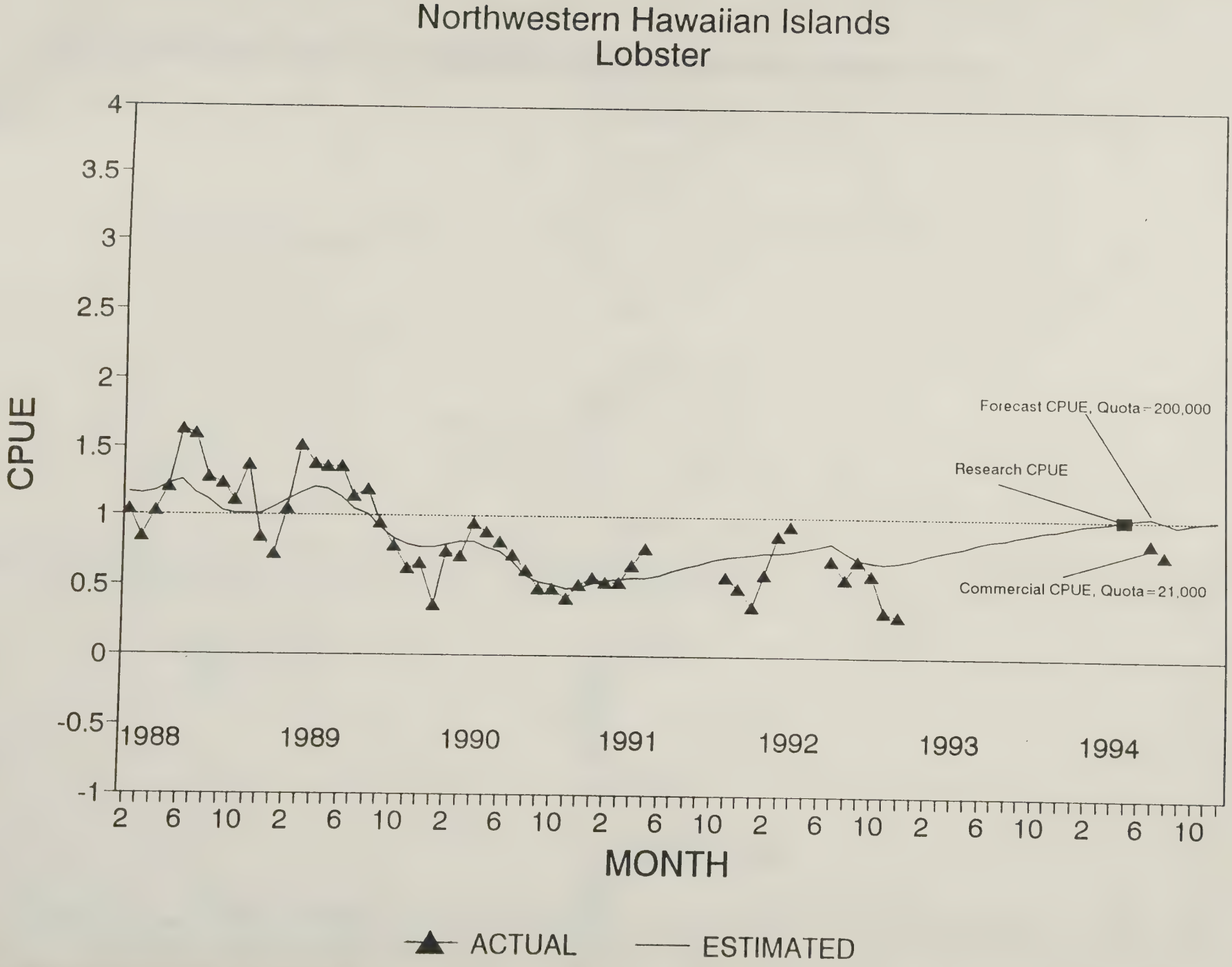

Figure 6. Monthly commercial CPUE and fit of the population model. The solid line projects the model fit through July 1994

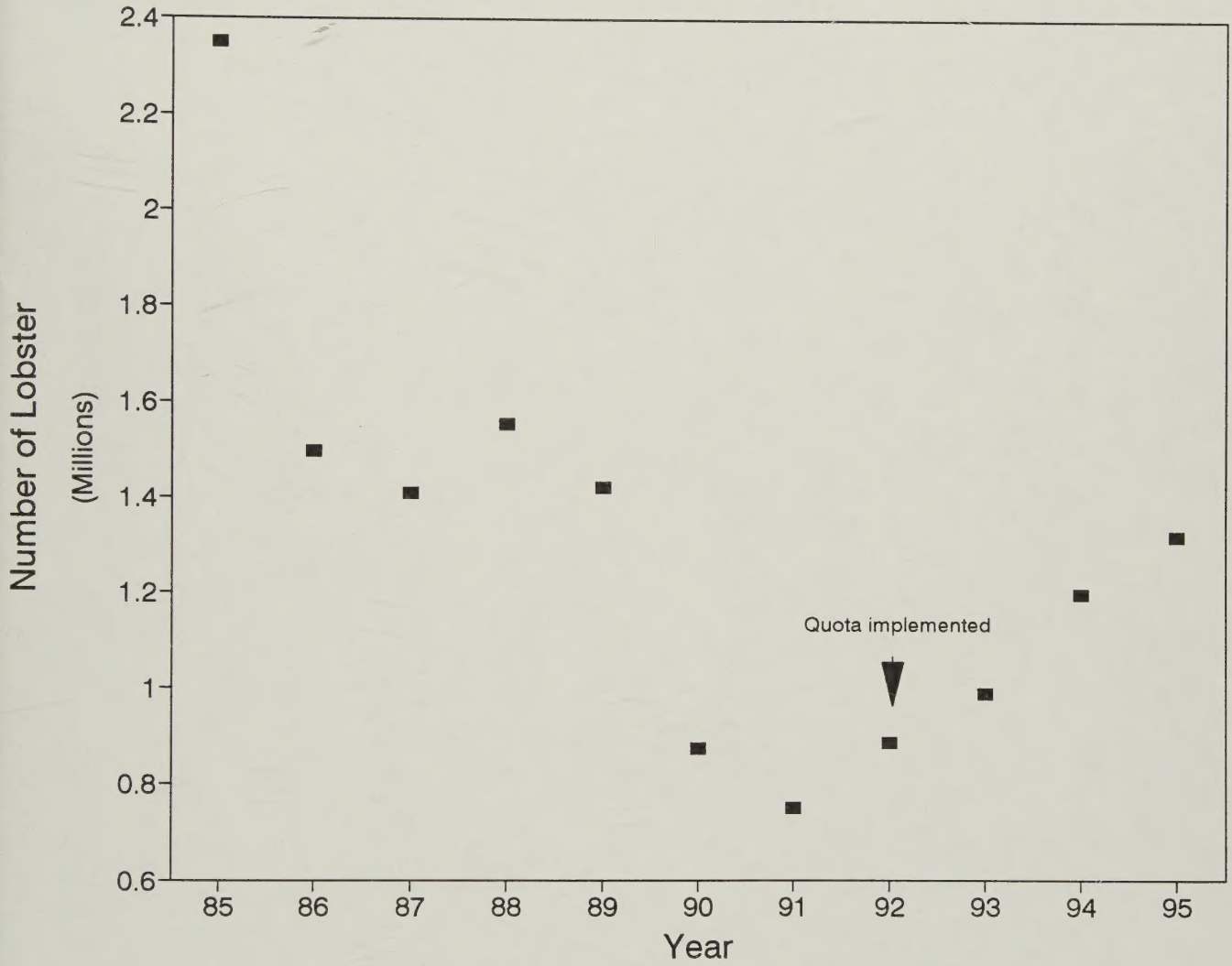

Figure 7. Estimate of the average annual exploitable NWHI lobster population (spiny and slipper lobsters combined) based on the population model.